Section 19 Groundwater

Tables

Figures

19 Groundwater

19.1 Introduction and Setting

Groundwater is not visually discernable and, as a result, it is difficult to quantify. This section describes the areal extent and volume of groundwater in the basin. It also describes groundwater quality along with present use and some development alternatives. Groundwater is used for public water supply, irrigation, domestic supply and for stock watering. Springs have always been the first to be developed by the early settlers. Later, after 1900, wells were developed. The climatic and geologic settings are described in subsection 3.3.

Groundwater is a particularly valuable source of water in the Kanab Creek/Virgin River Basin. It has had a major influence on the economic development and growth of the area. More data is needed from this area, however, to evaluate the extent of this water resource.

19.2 Groundwater Budget

Consolidated and unconsolidated aquifers store water used in the basin. These aquifers are supplied by precipitation infiltrating to the zone of saturation. Some water comes indirectly as streams cross aquifer recharge areas and by groundwater inflow into the basin.

The Navajo sandstone is the principal aquifer in the basin. Recharge to this groundwater aquifer is mostly by infiltration of precipitation and streamflow in outcrop areas. In some outcrop areas, highly permeable basalt enhances infiltration into the aquifer.

19.2.1 Precipitation

Much of the recharge takes place at higher elevations in the Pine Valley Mountains north of St. George, the Kolob Plateau above Zion National Park and the Markagunt Plateau around and east of Navajo Lake where the precipitation averages between 30 and 40 inches annually. Precipitation on the Paunsaugunt Plateau around Bryce Canyon National Park is somewhat less at about 20 to 25 inches annually. See Figure 3-3 for annual precipitation.

19.2.2 Recharge and Discharge[2]

A groundwater system is a storage reservoir. The amount of water in storage depends on recharge and discharge. On the average, the amount of groundwater discharge must be limited to the amount recharged back into the system. Discharging more water than is recharged over a long time will deplete the amount in storage. This may cause groundwater levels to drop and some springs and wells may begin to dry up.

Lowering water levels in the Navajo sandstone aquifer may reduce flow from springs along the outcrop near St. George. Unseen groundwater outflow may also be reduced. Reduction of spring outflow can impact water rights and may be a transfer of spring flow to well flow. This may be desirable in some respects, however, because the well flows are more convenient as they are available when needed. Reducing subsurface outflow is likely a net increase in available water, depending on if and where the groundwater outflow surfaces. Reducing the available water from springs may also have a negative impact on wildlife. Continuous monitoring would be needed to assure undesirable impacts do not result.

Artificial recharge may be a viable option, especially for the Navajo sandstone aquifer. Many streams cross the outcrop area. A few flow continuously, but most are ephemeral. To make more water available, recharge could be increased by building check dams and ponds and by spreading facilities in the stream courses to capture more of the unused high flows through infiltration. This could also have negative impacts on fish and wildlife.

The long-term average annual recharge in the Virgin River Basin is estimated to be the same as the discharge of 155,000 acre-feet. [2,3,4] In the central Virgin River Basin, the estimated average annual recharge of 105,000 acre-feet per year is greater than the discharge of 82,000 acre-feet per year for the years 1968-1970.[4] Similarly, the average annual discharge in the upper Virgin River Basin of 55,000 acre-feet per year is greater than the discharge of 49,000 acre-feet per year in 1977.[3] Recharge and discharge estimates generally will not balance unless the same base period is used. Time lag can also effect these estimates. Most groundwater not pumped from wells or used as evapotranspiration will eventually appear as streamflow.

Groundwater recharge and discharge in the upper Kanab Creek Basin (includes Johnson Wash) follow a similar pattern except at a smaller annual volume. The groundwater recharge from the Paunsaugunt Plateau and the East Fork of the Sevier River drainage north of the topographic divide of Kanab Creek is estimated at 6,000 acre-feet per year.[10] The groundwater recharge in upper Johnson Wash from these sources is much less. Sink Valley, lower Kanab Creek and Johnson Wash depend on infiltration of local direct precipitation and streamflow infiltration for groundwater recharge. An estimate of the groundwater recharge is shown in Table 19-1. Man-made withdrawal of groundwater is through wells used for public water supply, irrigation, domestic supply and for stock watering. Besides the use by wells, there is natural discharge through springs, seepage into streams, evapotranspiration by plants and subsurface outflow from the basin. The average annual discharge from

TABLE 19-1
ESTIMATED AVERAGE ANNUAL GROUNDWATER RECHARGE[1,3,4,6,10]

Source	Virgin River (acre-feet) Central	Virgin River (acre-feet) Upper	Kanab Creek & Johnson Wash (acre-feet)
Precipitation infiltration[a,b]	70,000	55,000[c]	25,500[c]
Streamflow infiltration	15,000	NA	NA
Subsurface inflow	20,000	10,500[d]	6,000[d]
Total	105,000	65,500	31,000

[a]Includes precipitation and streamflow infiltration. Data is incomplete.

[b]Current estimates for the upper Virgin River, Kanab Creek, Johnson Wash and Paria River range from 5,500 to 110,000 acre-feet.[6]

[c]Estimated for year 1977.

[d]Brown, H. T. Hydrogeology of the Markagunt Plateau, Sevier River Basin Summary Report and appendices, USDA.

Note: Recharge varies depending on time periods used for estimates.

TABLE 19-2 ESTIMATED AVERAGE ANNUAL GROUNDWATER DISCHARGE[2,3,4]			
Source	Virgin River		Kanab Creek &
	Central[a]	Upper[b]	Johnson Wash[b]
	(acre-feet)		(acre-feet)
Seepage into streams	23,500	42,000	8,000
Flow from springs and drains	36,000	10,500[c]	800
Well withdrawal	7,600	1,300	2,000
Evapotranspiration	13,000	4,000	6,000
Subsurface outflow	2,000	unknown	5,000
Total	82,100	57,800	21,800

[a]Average for 1968 and 1970

[b]1977

[c]Includes La Verkin (Pah Tempe) Spring

Note: Discharge varies depending on time periods used for estimates.

the Virgin River Basin depends on the years averaged. The supply for municipal and industrial uses coming directly from groundwater were estimated at 13,000 acre-feet in 1983[2]. Studies are underway to update the data.

The base flow of the East Fork of the Virgin River and of the upper and lower Kanab Creek comes from springs and seepage into the riverbed. These springs are in many formations throughout the whole geologic section; they begin at the Lamb Point Tongue of the Navajo sandstone and continue with interruptions up to the Brian Head formation in the Sevier River drainage.

Table 19-2 shows available estimates of annual groundwater discharge for specific years in the Virgin River Basin. The values shown are broken down into the central Virgin River area west of the Hurricane Fault and the upper Virgin River area east of the Hurricane Fault. The values would be different for different years or time series. For example, Table 19-2 shows the 1968 and 1970 average for withdrawal from wells in the central Virgin River area to be 7,600 acre-feet.[4] The volume has increased substantially since then. The 1975-85 average is 19,400 acre-feet.[2] During 1982, which was a high year, 27,000 acre-feet were withdrawn.

Discharge to streams is estimated as follows: North Fork Virgin River, 14,500-28,000 acre-feet; East Fork Virgin River, 23,700-26,000 acre-feet; and Kanab Creek, 1,600-3,700 acre-feet. Discharge to springs is about 10 percent of these values (Heilweil and Freethey[6]). The creek in Johnson Wash is ephemeral in those stretches flowing on outcrops of the Lamb Point Tongue of the Navajo sandstone about six miles north of its mouth.

Other estimates for Kanab Creek and Johnson Wash indicate the following: seepage, 2,500 acre-feet; springs, 5,100 acre-feet; wells, 1,000 acre-feet; evapotranspiration, 1,500 acre-feet and subsurface outflow, 4,000 acre-feet.[6] This re-emphasizes the variability depending on the time period used.

19.2.3 Transbasin Groundwater Inflow

Much of the northern divide of the Kanab Creek-Virgin River Basin in the Markagunt and Paunsaugunt plateaus is formed by south-facing cliffs of pink limestone of the Claron Formation. Springs issue from the base of these cliffs in many places, draining groundwater which is recharged north of the topographic divide. The best documented case is that of Cascade Spring, south of Navajo Lake (Wilson and Thomas, 1964). Therefore, much of the groundwater divide between the Kanab Creek/Virgin River Basin and the Sevier River Basin lies somewhat north of the topographic divide. This is the source of over 16,000 acre-feet of groundwater inflow.

19.2.4 Groundwater Storage

The unconsolidated aquifers presently produce more water than the consolidated rock formation such as the Navajo sandstone; however, total groundwater storage is greater in the consolidated formations. The volume of relict water is unknown.

The Navajo sandstone is the largest consolidated aquifer in the basin. This is a fossil dune sand and is up to 2,200 feet thick in some places. It has a permeability ranging from 0.5 to 50 feet per day, depending on the intensity of fracturing. Its storage coefficient ranges from 0.001 to 0.10[8]. The Navajo sandstone is exposed in or underlies about three-fourths of the area of the basin and is estimated to contain several million acre-feet of recoverable water. Other consolidated formations that contain water in recoverable quanities are the Claron Formation, the Straight Cliffs and Wahweap sandstone[3], the Carmel, Kayenta, Moenave, Chinle (Shinarump member) and Moenkopi formations, the Kaibab limestone and the Tropic and Dakota shale. Any groundwater used from these aquifers is restricted by several factors. These include legal, environmental, technological and economic restraints. Water quality is marginal to poor in some of these formations.

Virgin River - It appears most of the recoverable groundwater in the central and upper Virgin River basin is in the Navajo sandstone. Since the thicknesses and areas of the aquifers are similar in the two basins, the larger difference in recoverable groundwater must be explained by other aquifer characteristics.

The explanation lies in the different shape and depth of the aquifer east and west of the Hurricane fault. West of the fault, the Navajo sandstone aquifer has a distinctive saucer shape with the lip or high edge of the saucer corresponding to the southern and eastern edges of the aquifer outcrop. The bottom of the aquifer plunges deeper to near sea level or below as it dips northward under the Pine Valley Mountains.

East of the Hurricane fault, the Navajo sandstone aquifer is more nearly horizontal, especially to the north of the Virgin River, and is exposed or close to the surface in many areas. Recovery of the groundwater is probably more feasible than in the deeply buried Navajo sandstone west of the fault, but little development has taken place because of its location in and above Zion National Park.

Kanab Creek and Johnson Wash - The greatest potential source of water in the Kanab Creek and Johnson Wash drainages is the Navajo sandstone. Within the Navajo sandstone, the two most favorable water bearers are the base of the massive upper member, probably about 1,200 to 1,500 feet below the top of the Navajo sandstone in Johnson Wash, and the base of the Lamb Point Tongue, which is about 400 to 500 feet thick and separated from the upper member in the vicinity of Johnson Wash by about 100 feet of the Tenney Canyon Tongue of the Kayenta formation. The Navajo sandstone may approach 2,000 feet as a single unit near Alton.

The water in both units of the Navajo sandstone is generally of excellent quality, generally of better quality than available surface water. Analyses of water from 11 test wells in the Navajo sandstone range from 200 to 1,495 mg/l in total dissolved solids (TDS), with an average of 460 mg/l (Bingham Engineering, 1987, Table B-1). Analyses of 75 springs in the upper member of the Navajo range in TDS from 62 to 1,135 mg/l, with an average of 275 mg/l (op.cit., Table B-7). Analyses of 35 springs in the Lamb Point Tongue of the Navajo range from 80 to 1,030 mg/l and average 320 mg/l (op. cit. Table B-8).

The greatest depths to the base of the Lamb Point Tongue are a little more than 3,000 feet, and the shallowest depths are in the vicinity of Johnson Wash where the Lamb Point Tongue crops out and forms the surface over large areas. If the bottom 200 feet of either the massive upper member or the Lamb Point Tongue is saturated, then the Navajo sandstone in this area could contain several million acre-feet of water in the 300-square mile area. See Figure 19-1.

Water quality in both formations tends to be better higher in the tributaries, but good and poor water quality may be found in many areas. Water from the Navajo sandstone aquifer is generally good; however, there are exceptions. The unconsolidated aquifers generally have poorer quality water in the lower elevations of the basin due to discharge from some geological formations that contain soluble minerals.

19.2.5 Wells

Existing wells in the Kanab Creek/Virgin River Basin are good indicators of extent, location and amount of groundwater development. Over 750 wells are located within the basin.[2] Since most wells are developed as near as possible to the point of use, the wells show where groundwater is used. Some municipal wells are located at a distance from the actual use of the water. Well locations are shown in Figure 19-2.

Most wells in the basin do not show any long-term rise or fall in the water levels. Two, however, do show declines in response to increased pumping.[2] The first well, located in the Navajo sandstone aquifer near Gunlock, has dropped 22 feet since 1971. The second well, in unconsolidated rock in

FIGURE 19-1
Schematic Geologic Section, Kanab Block, Kane County

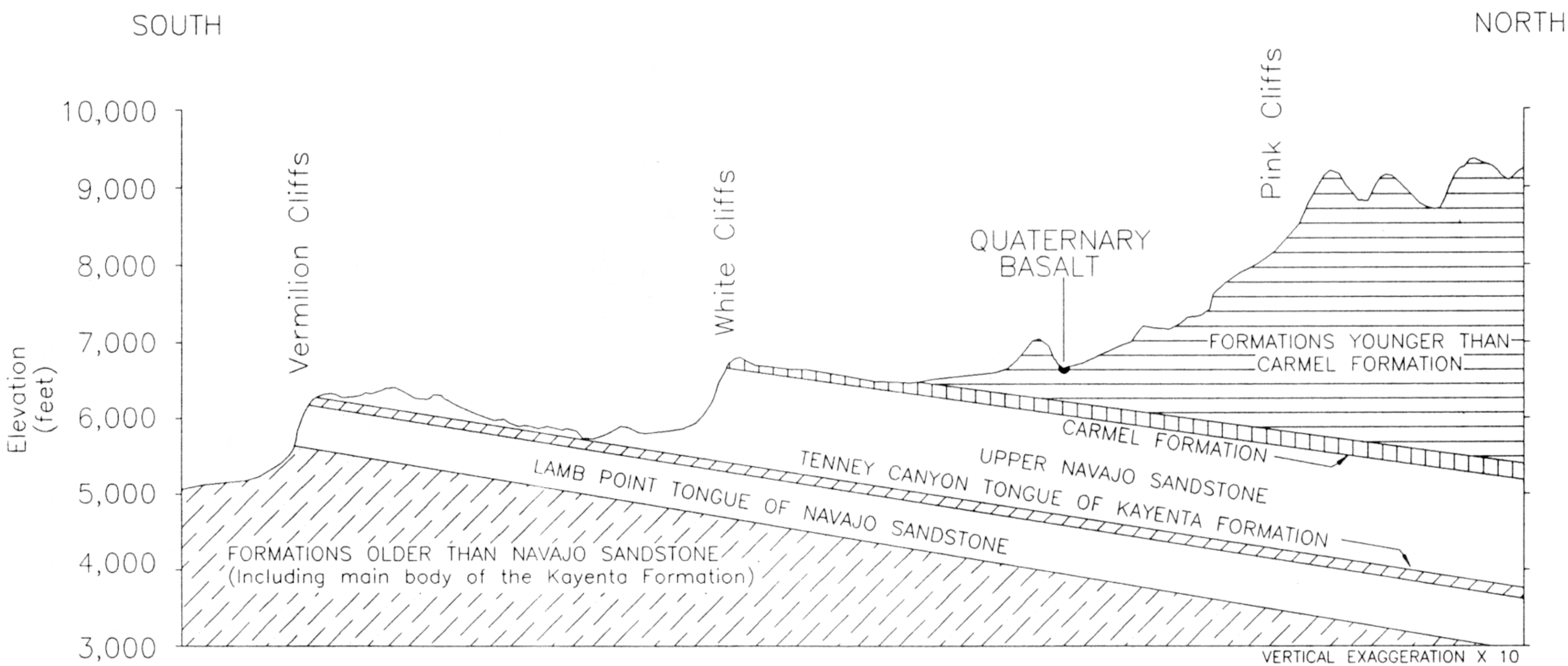
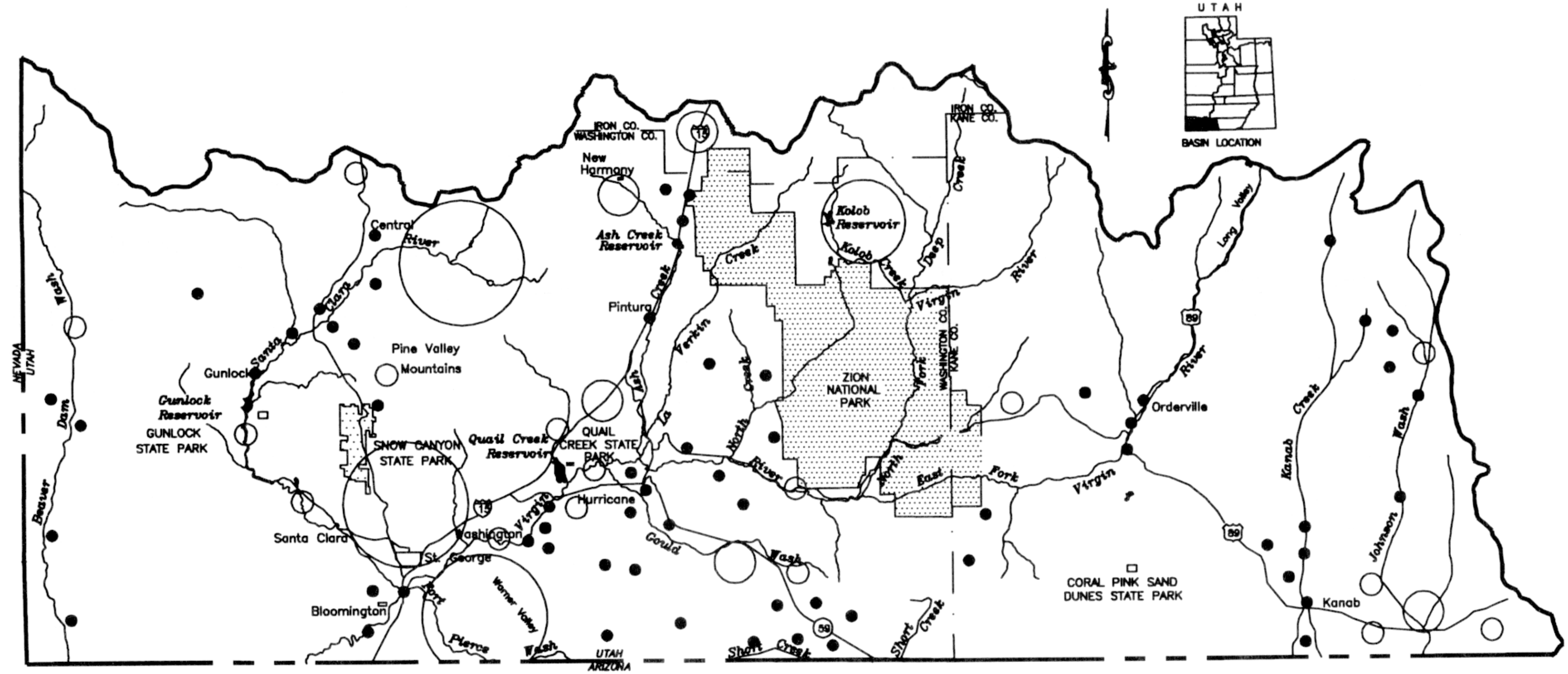


FIGURE 19-2
Well Locations



Source: Groundwater Resources of the Virgin River Basin; Clyde
Ground–Water Conditions in the Upper Virgin River and Kanab Creek Area, Utah; Cordova

LEGEND: Number of wells in vicinity.

1–5 ● 6–10 ○ 11–15 ○ 16–25 ○ +25 ○

Fort Pierce Wash near the Arizona border, has dropped 45 feet since 1961. There is no evidence of long-term draw down in any wells in the East Fork of the Virgin River, Kanab Creek or Johnson Wash drainages. Even though available data do not show any widespread downward trend in well water levels, the downward trend in the two wells and the lack of data in other areas should motivate the collection of additional water level and pumpage data.

Most of the growth in irrigation well development occurred after 1950. The irrigation, domestic and stock wells are scattered around the basin while public water supply wells are clustered near cities. Most of the big public water supply wells are found at Gunlock, Snow Canyon and Mill Creek Canyon in and around St. George City. Kanab City has developed wells in Kanab Canyon. There are a total of 13 wells in the Kanab and Cottonwood canyons.

Potential exists for development of additional water by drilling wells at favorable locations. Wells drilled to penetrate the Navajo sandstone will yield from 400 to 1,500 gallons per minute. Yield depends on the thickness of the saturated zone and the extent of jointing and fracturing in the rock. About one-half of the wells yield water with dissolved-solids concentrations of less than 500 mg/l.

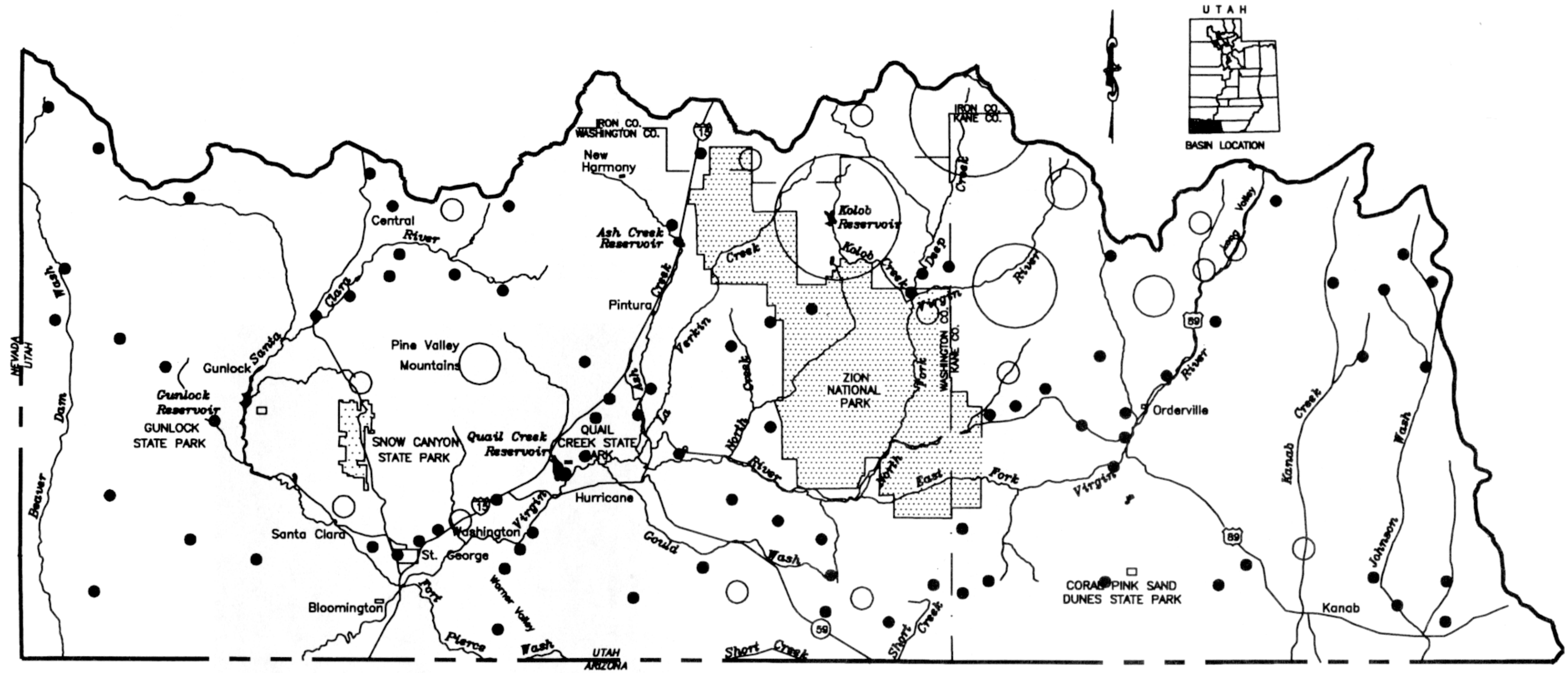
19.2.6 Springs

Springs are places where water spills from full groundwater reservoirs. Flows from the springs in the basin range from seeps to 10s of cubic feet per second (cfs). The basin has nearly 900 springs.[2] Toquerville Springs are the largest. The upper spring has been measured at greater than 21.7 cfs. If the lower springs are added in, the flows have exceeded 30 cfs. Total dissolved solids are about 450 mg/l.

La Verkin Springs (Pah Tempe) also produce a substantial amount of water, but it has poor quality. The total dissolved solids exceed 9,000 mg/l. About 12 cfs flows from these springs into the bed of the Virgin River just east of the Hurricane Fault near the town of La Verkin.

Most springs are located at higher elevations in steeper terrain. Location of the springs is shown in Figure 19-3. In some cases, wells and springs are near each other and draw on the same aquifer. An example is the springs near the edge or lip of the Navajo sandstone near St. George, in Pine Valley and in Kanab Creek and Johnson Wash. In general, spring flows are determined by long-term precipitation

FIGURE 19-3
Spring Locations



Source: Groundwater Resources of the Virgin River Basin; Clyde
Ground-Water Conditions in the Upper Virgin River and Kanab Creek Basins Area, Utah; Cordova

LEGEND: Number of springs in vicinity.

1–5 ● 6–10 ○ 11–15 ○ 16–25 ○ +25 ○

patterns reflecting wet and dry cycles. About 50 percent of the springs yield water with less than 500 mg/l total dissolved solids.

19.3 Policy Issues and Recommendations

Two policy issues are discussed. These concern alternatives for groundwater development.

19.3.1 Groundwater Development

Issue - Future water needs will increase pressure on developing additional groundwater resources.

Discussion - Large volumes of high quality water are stored in the groundwater aquifers, particularly in the Navajo sandstone. More and more of this water resource is being developed. The recharge to this aquifer is slow, so care will be necessary to control groundwater mining. Use of groundwater should be tempered by its effect on water quality. Limited opportunities exist for artificially enhancing aquifer recharges. The recent study completed in Kane County through the coordinated efforts of federal, state and local entities indicates future possibilities.

Recommendation - The Utah Department of Natural Resources, U.S. Geological Survey and local government entities should conduct the necessary groundwater studies to determine the available resources and extent of use possible.

19.3.2 Protection of Recharge Areas

Issue - Groundwater recharge areas to the Navajo sandstone aquifer will become more susceptible to pollution as man's activities increase.

Discussion - Recharge maps have been developed by the U.S. Geological Survey in cooperation with the Division of Water Quality. A map of part of the area is shown in Figure 9-2. The recharge areas are environmentally sensitive and essentially the gateways to a valuable drinking water source. Any pollution spill onto these areas has a potential to contaminate drinking water taken from the Navajo sandstone and other aquifers. Recharge areas should be protected from degradation in accordance with the Utah groundwater protection regulations. County commissioners and planners should work to protect recharge areas, including ordinances if needed.

Recommendation - The Navajo sandstone recharge areas should be identified in local master plans. Local government entities should investigate management approaches in protecting these areas from potential sources of groundwater pollution. ■

19.4 References

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■ **State Water Plan** - Kanab Creek/Virgin River Basin

Prepared by the State Water Plan Coordinating Committee

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